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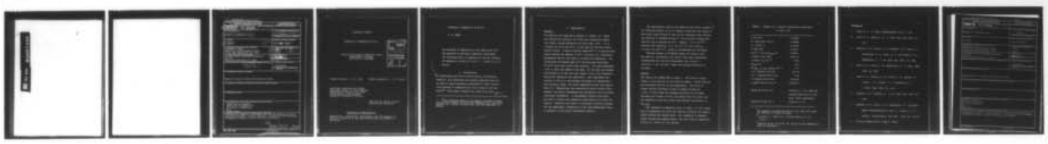

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COMBUSTION CALORIMETRY
GROSS HEAT OF COMBUSTION
NET HEAT OF COMBUSTION
RJ-6
RAMJET FUELS

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The enthalpy of combustion of the ramjet fuel RJ-6 was measured by precision combustion calorimetry. The following value is reported for the net enthalpy of combustion at 298.15 K (25° C): -(17971.8 ± 0.4) Btu/lb.

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SCIENTIFIC REPORT

ENTHALPY OF COMBUSTION OF RJ-6

Bartlesville Energy Technology Center
Department of Energy
Bartlesville, Oklahoma

Project Director: W. D. Good

Report prepared by: N. K. Smith

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Enthalpy of combustion of RJ-6 [a]

N. K. SMITH

The enthalpy of combustion of the ramjet fuel RJ-6 was measured by precision combustion calorimetry. The following value is reported for the net enthalpy of combustion at 298.15 K (25° C): -(17971.8 ± 0.4) Btu/lb.

1. Introduction

In cooperation with the Air Force Office of Scientific Research, this laboratory has studied compounds that may be used to impart particular properties to fuels such as high enthalpy of combustion per unit volume or per unit mass.[1] This report concerns the ramjet fuel RJ-6.

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[a] Work conducted under an Interagency Agreement between the Air Force Office of Scientific Research, U.S. Air Force, Contract No. 78-0009, Project 2308, and the Department of Energy.

2. Experimental

MATERIAL

The material was supplied by Herbert R. Lander, Jr., Fuels and Lubrication Division, Air Force Aero Propulsion Laboratory (AFSC), Wright-Patterson Air Force Base, Ohio. It is a mixture of JP-10 and RJ-5; it was used as received without further drying. Fragile flexible ampoules[2,3] of borosilicate glass confined the samples of RJ-6; auxiliary oil (laboratory designation TKL 66) was used to initiate the combustion. Rotating-bomb calorimeter BMR II[4] and platinum-lined bomb Pt-3b[5] were used without bomb rotation. For each experiment, 1 cm^3 of water was added to the bomb, and the bomb was flushed and charged to 30 atm with pure oxygen; nitric acid formation during the combustion was negligible. Each experiment was started at 296.15 K, and because the masses of combustibles were properly chosen, the final temperatures were very nearly 298.15 K. Temperatures were measured by quartz crystal thermometry; the quartz thermometer was calibrated with a platinum resistance thermometer. A programmable desktop calculator was used to control the combustion experiments and record the results. Readings were taken at 100-second intervals throughout the experiment; integration of the time-temperature curve is inherent in the quartz thermometer reading.

The experimental results are based on 1961 atomic weights.[6] For reducing weights in air to masses, converting the energy of the actual bomb process to that of the isothermal bomb process, and reducing to standard states,[7] the following values were used for the properties of RJ-6: density, 1.01 g cm^{-3}[8]; specific heat capacity, (0.3) cal K^{-1} g^{-1}; and $(\partial E/\partial P)_T$, (-0.003) cal atm^{-1} g^{-1}; values in parentheses are estimates.

National Bureau of Standards sample 39i benzoic acid was used for calibration; the result from eight experiments interspersed with the RJ-6 experiments was ε(calor) = (4005.82 ± 0.05) cal deg^{-1} (mean and standard deviation of the mean).

RESULTS

The results are summarized in table 1. The value of $\Delta E_c^\circ/M$ refers to the reaction of unit mass of sample. Carbon dioxide was recovered from all of the experiments. The ratio of carbon dioxide recovered to mass of sample burned was 3.2725 ± 0.0002 (mean and standard deviation of the mean). The empirical formula of RJ-6 calculated from this ratio and the assumption that only carbon and hydrogen are present is $CH_{1.4259}$.

The enthalpy of combustion given in table 1 is the "gross" heat of combustion for which the reaction products are gaseous carbon dioxide and liquid water. For combustion to gaseous carbon dioxide and gaseous water, the "net" heat of combustion of RJ-6 is -(17971.8 ± 0.4) Btu/lb.

TABLE 1. Summary of a typical calorimetric experiment at 298.15 K[a]

$m'(RJ\text{-}6)/g$	0.720016
$m''(\text{auxiliary oil})/g$	0.038964
$m'''(\text{fuse})/g$	0.001056
$n^i(H_2O)/mol$	0.05535
$\Delta t_c/K = (t_f - t_i + \Delta t_{corr})/K$	2.00000
$\varepsilon(\text{calor})(-\Delta t_c)/cal$	-8011.63
$\varepsilon(\text{cont})(-\Delta t_c)/cal$ [b]	-8.80
$\Delta E_{ign}/cal$	0.18
$\Delta E_{(\text{corr to std states})}/cal$ [c]	3.31
$[-m''(\Delta E_c^\circ/M)(\text{oil})]/cal$	428.78
$[-m'''(\Delta E_c^\circ/M)(\text{fuse})]/cal$	4.28
$[m'(\Delta E_c^\circ/M)(RJ\text{-}6)]/cal$	-7583.88
$[(\Delta E_c^\circ/M)(RJ\text{-}6)]/cal\ g^{-1}$	-10532.93
$\Delta E_c^\circ/M)(RJ\text{-}6)/cal\ g^{-1}$	$-(10533.05 \pm 0.24)$ mean and standard deviation of the mean, seven experiments
$\Delta E_c^\circ/M(RJ\text{-}6)/Btu\ lb^{-1}$	$-(18946.8 \pm 0.4)$

[a] The symbols and abbreviations of this table are those of reference 7 except as noted.

[b] $\varepsilon^i(\text{cont})(t_i - 298.15\ K) + \varepsilon^f(\text{cont})(298.15\ K - t_f + t_{corr})$.

[c] Items 81 to 85, 87 to 90, 93, and 94 of the computation form of reference 7.

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